Appendix M. Hydrology

The 2006 event was characterized by a seasonal runoff volume that was slightly above average. However the shape of the runoff was unusual due to several factors. Record temperatures in the basin in mid-May resulted in very rapid snowmelt and a peak in inflow during the second and third week of May. In addition, rainfall during the second half of May and the first part of June was above normal in the Kootenai Basin. In particular, record rainfall of up to 266% of normal was experienced at Libby Dam in June. This resulted in higher than anticipated inflows to Libby Dam based upon previous forecasts.

The detailed description of the 2006 event and the specific hydrologic, meteorologic, and other information that was used to make water management decisions is described in Appendix K (Water Management) as well as Appendix W (National Weather Service River Forecast Center).

The purpose of this Hydrology Appendix is to provide information on the hydrographs for various stream gages in the Kootenai River Basin, flood peak frequency estimates for various streams, and flood duration frequency estimates for Bonners Ferry, Idaho to help put in context the nature and magnitude of this event.

Most of the data presented in this report were collected in near real-time during the 2006 runoff season. While care is taken in data collection to assure quality and accuracy, the data have not undergone a thorough quality control review. Data should be verified with the U.S. Geological Survey, the National Weather Service, or other agencies responsible for data collection in applications where a high level of confidence in data accuracy is important. Libby Dam inflow and outflow data is calculated by Corps and is taken from the Corps Data Query Site (provide internet address).

A. Hydrographs.

Hydrographs for various stream gages in the Kootenai basin are shown in Figures 1-8. The majority of locations saw higher peak flows in May (primarily from snowmelt) than in June (primarily from rain) Figure 8 shows river stages at Bonners Ferry, as regulated by Libby Dam, and compares them to unregulated river stages without Libby Dam in place. It should be noted that the May peak at Bonners Ferry was significantly reduced (an observed peak stage of 1763.2 feet, compared to an estimated unregulated peak stage of 1776.3 feet) by the operation of Libby Dam, while the June peak was moderately reduced (observed peak stage of 1766.6 instead of an estimated unregulated peak stage of 1770 feet).

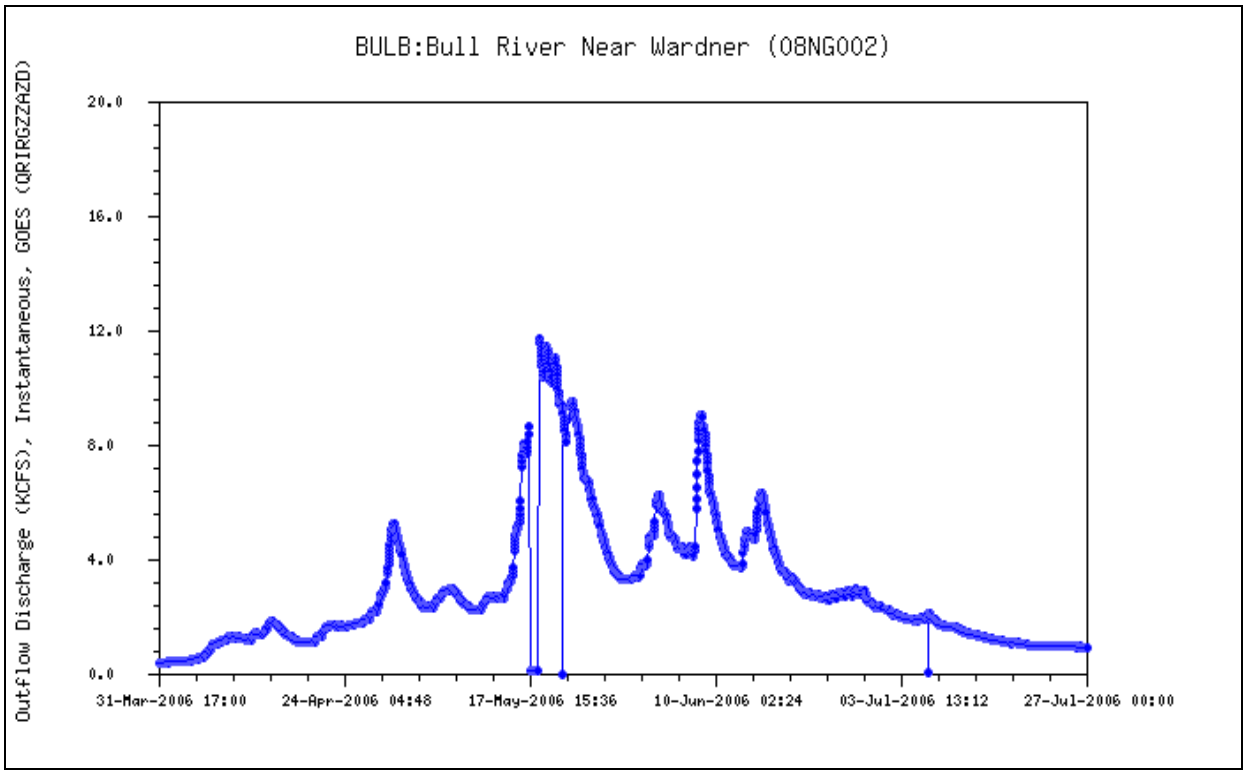

Figure 1. Bull River near Wardner

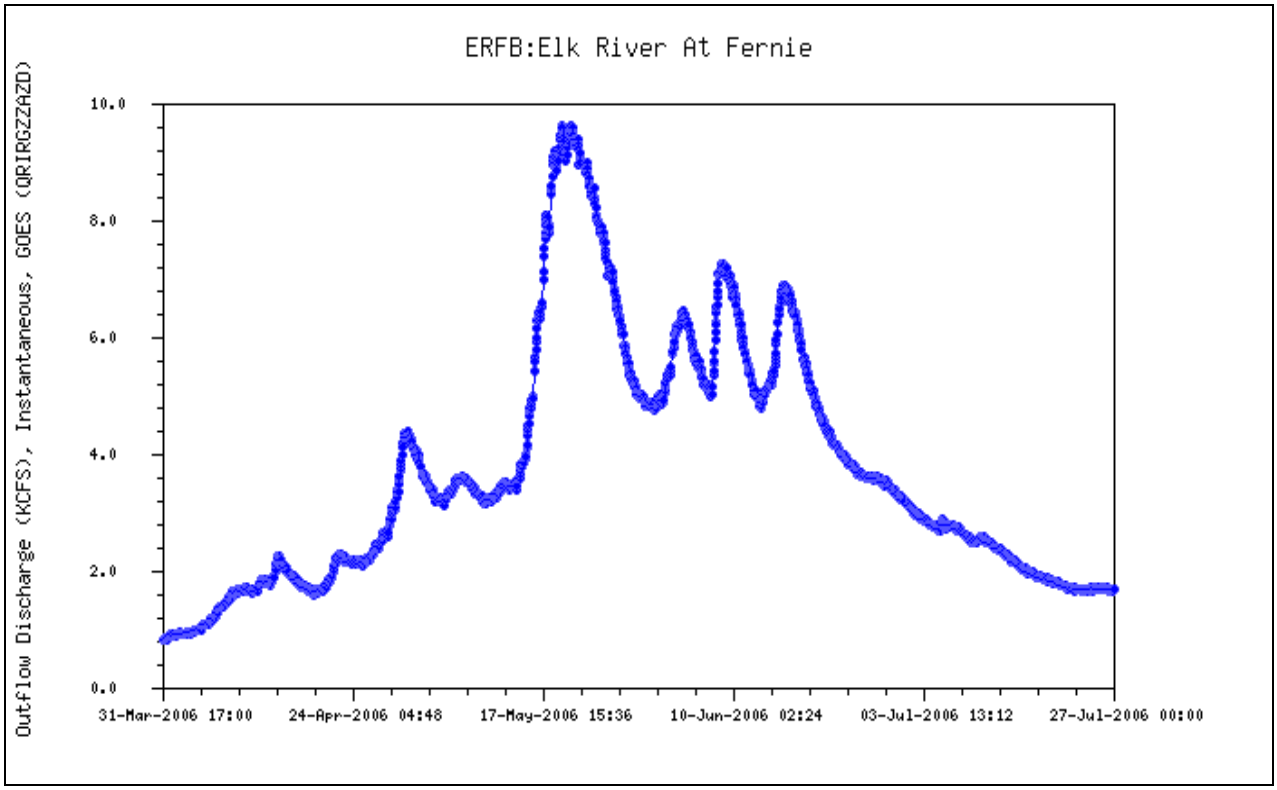

Figure 2. Elk River at Fernie

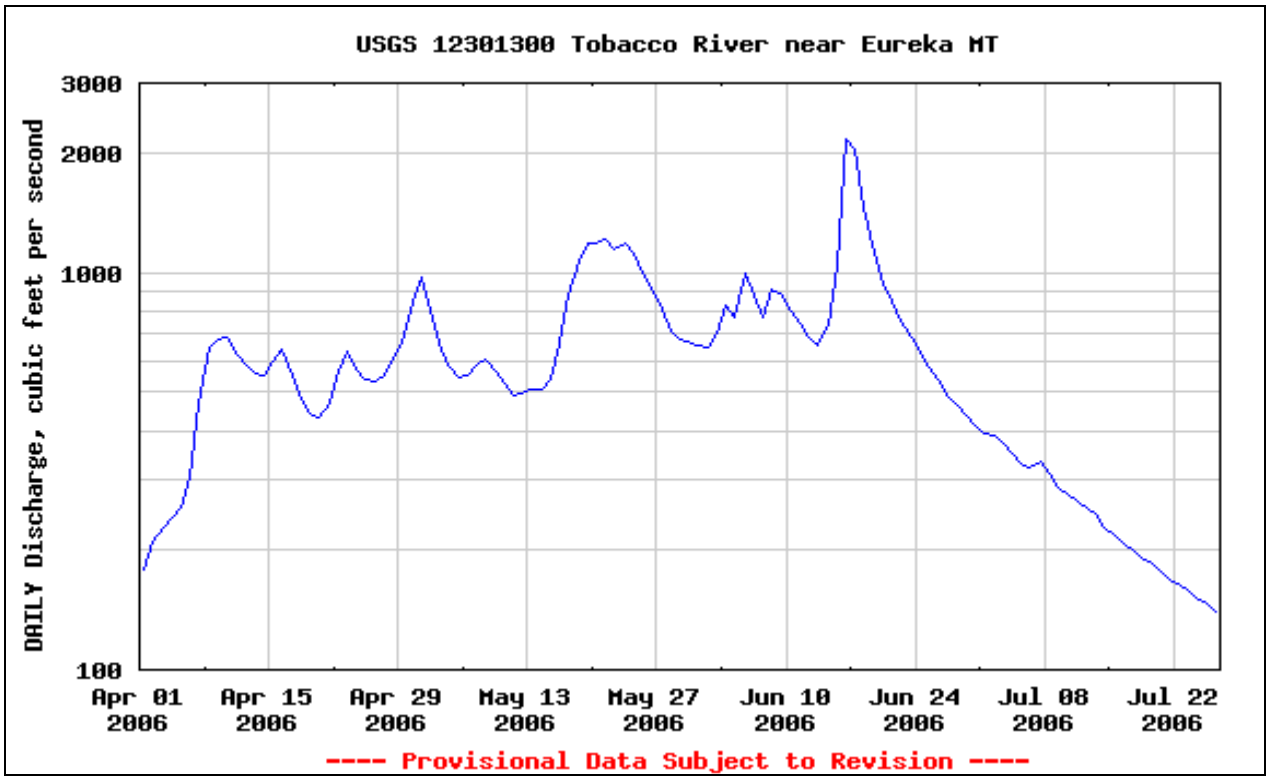

Figure 3. Tobacco River near Eureka

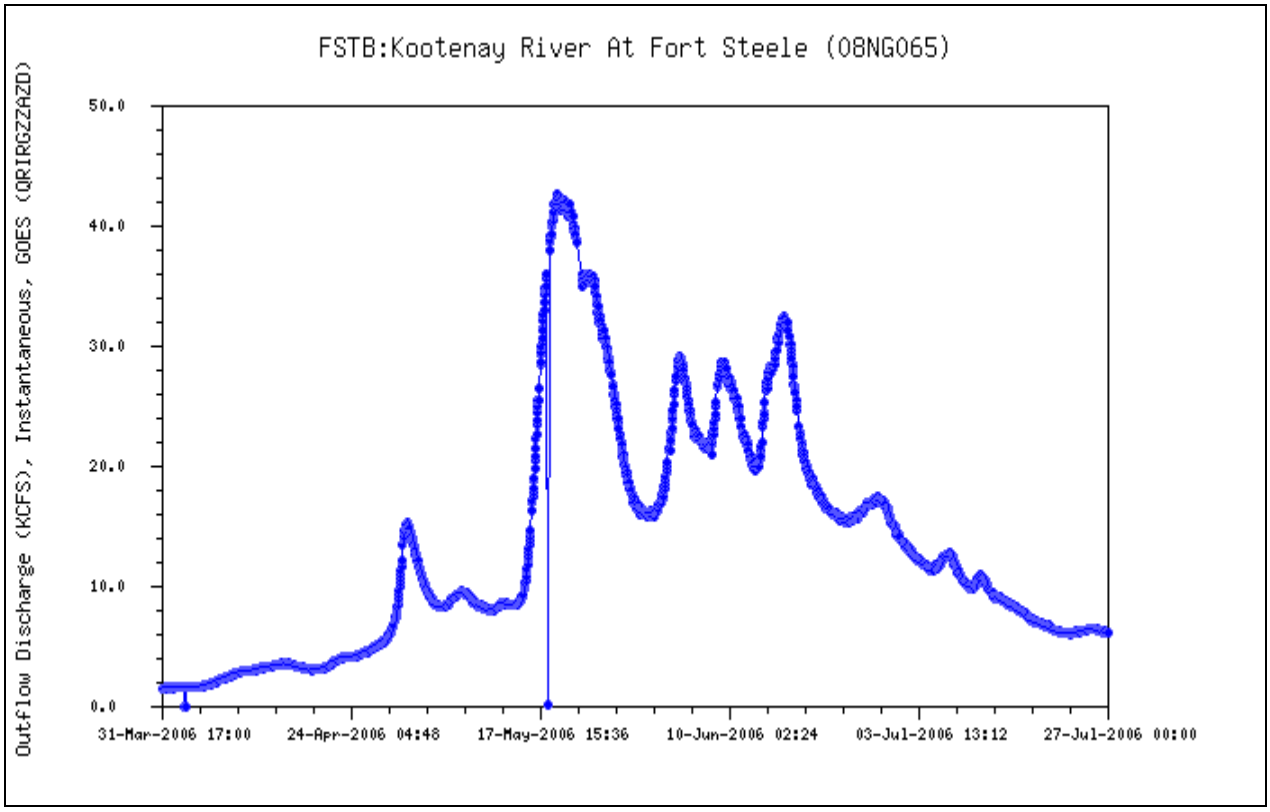

Figure 4. Kootenay River at Fort Steele

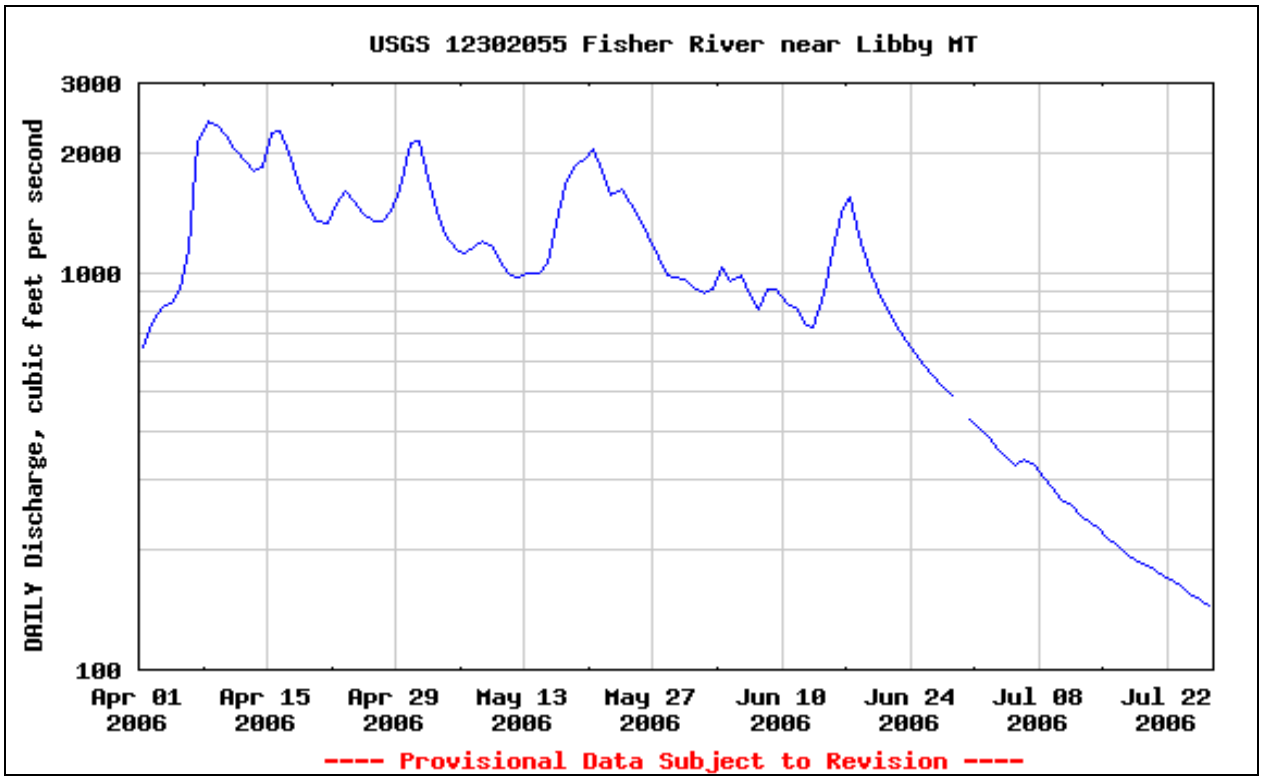

Figure 5. Fisher River near Libby

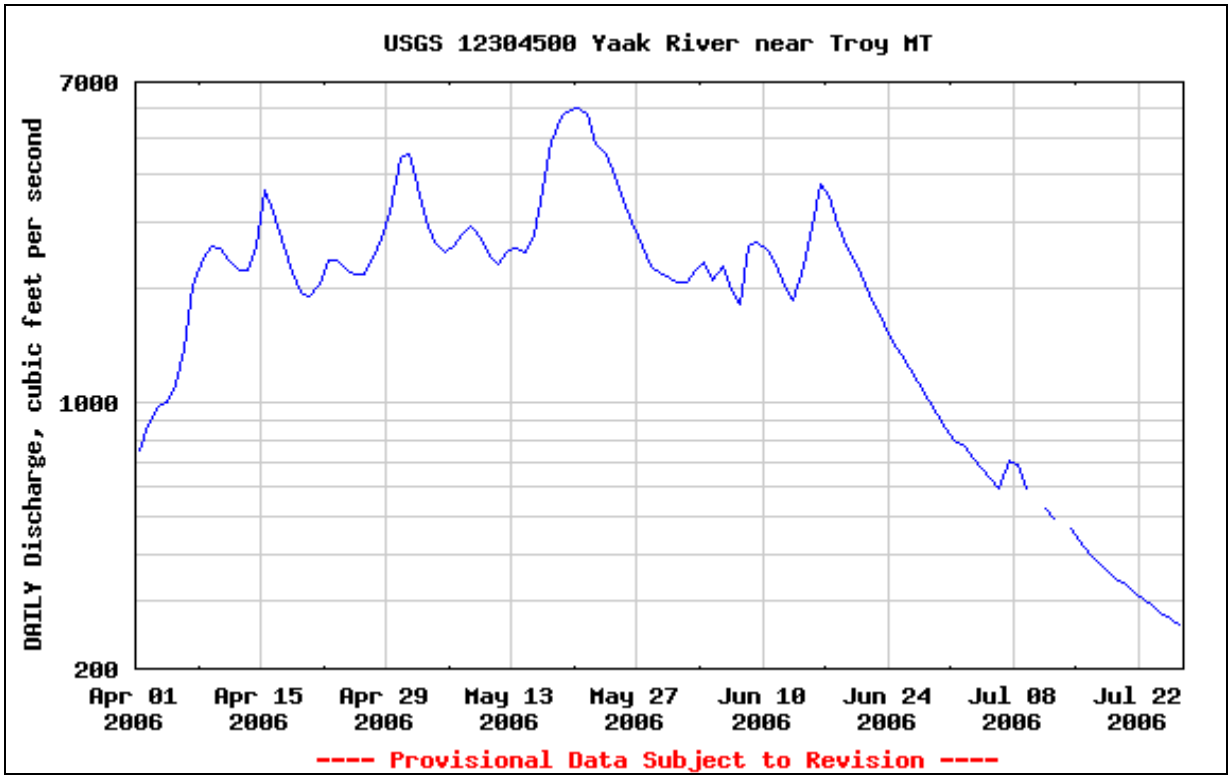

Figure 6. Yaak River near Troy

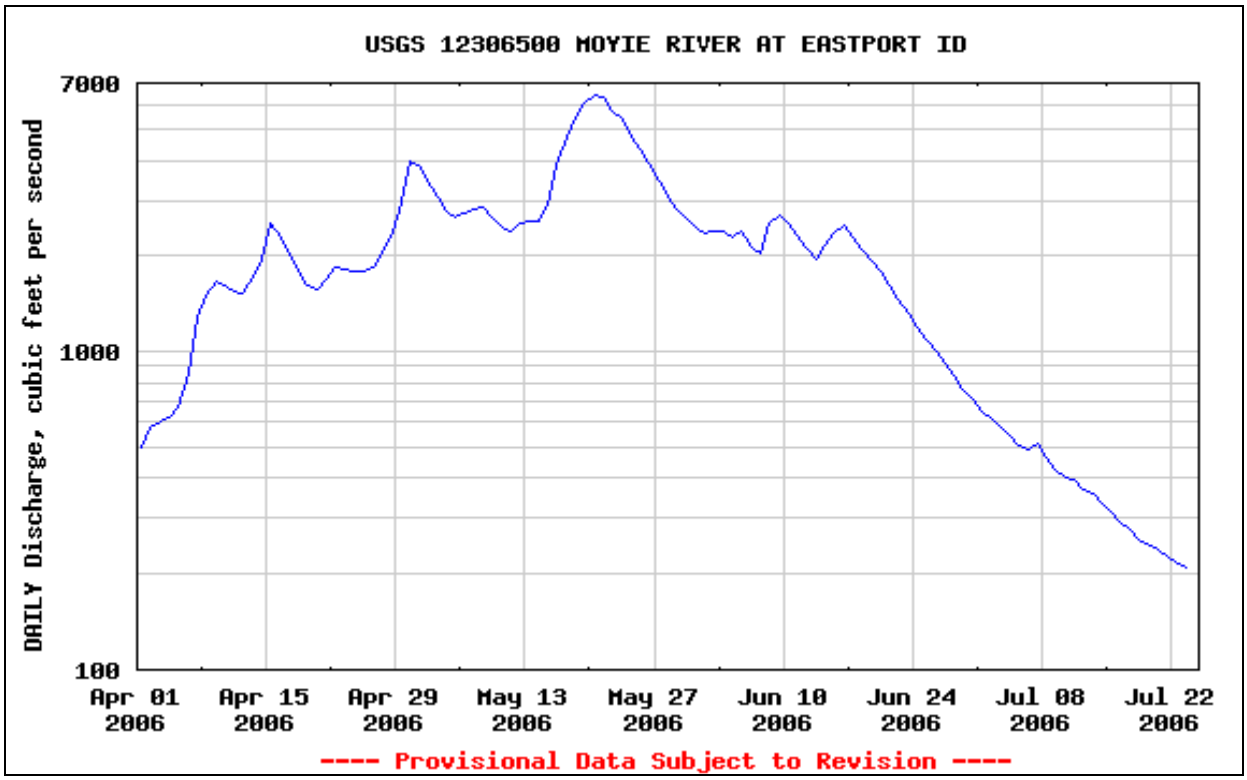

Figure 7. Moyie River at Eastport

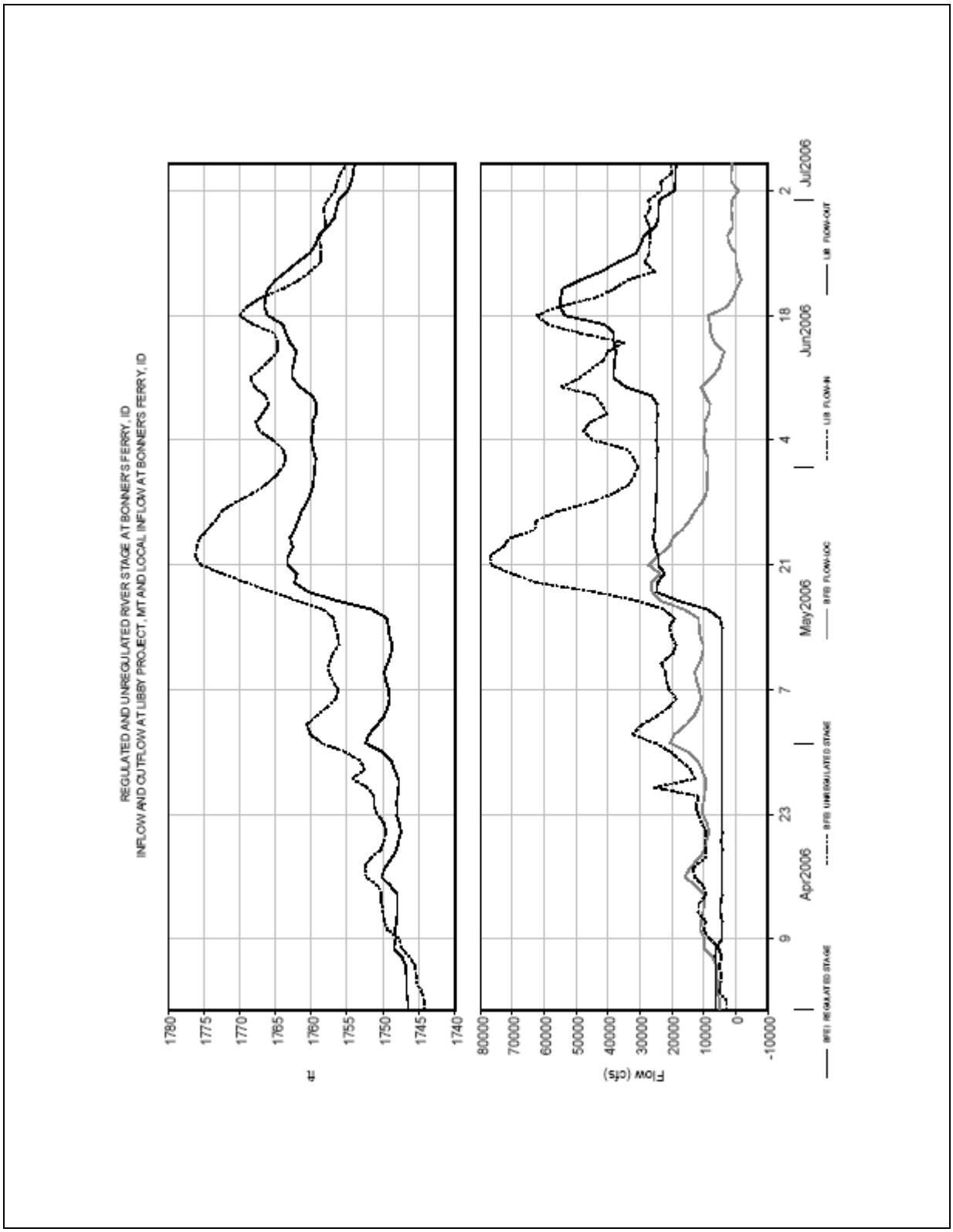

Figure 8. Kootenai River at Bonners Ferry, Regulated and Unregulated

B. Flood peak frequency estimates.

Estimates of the flood peak frequency are developed to assist in characterizing the runoff event. A low exceedance frequency indicates that based on historical information, the flood peak does not occur very often. A high exceedance frequency indicates that the flood peak occurs on a more frequent basis.

The 2006 runoff event in the Kootenai basin produced flood peak exceedance frequencies ranging between 0.7% and 78%. In general, most gages experienced the highest flows during the latter half of May, when several days of record daily temperatures caused above normal snowmelt. During June, when heavy rain fell in the basin, water levels again came up, but they were generally lower than what occurred in May. The exception to this observation is the Tobacco River near Eureka, where the June peak exceeded that in May. Flood peak frequency estimates for various streamgages are shown in Table 1

TABLE 1 Flood Peak Frequency – Observed Data – 2006 Runoff Season

Streamgage Name	Station Number	Peak Stage Feet Date	Peak Discharge (cfs)	Exceed Freq %	Recurrence Interval Years	Frequency Curve Source and Date
Libby Dam Outflow	USGS 12301920	2129.4 June 18	55,000	0.7	143	Water Control Manual 1984 Chart 4-1
Moyie River @ Eastport	USGS 12306500	9.24 May 17	6740	23%	4.3	Source
Yaak River near Troy	USGS 12304500	7.89 May 19	6570	46%	2.2	USGS Website* 9/13/2006 based on Bulletin 17b
Fisher River near Libby	USGS 12302055	6.31 April 8	2400	78%	1.3	USACE Seattle District 1999
Kootenai River @ Ft. Steele	BC WDR 08NG065	14.84 May 20	42530			Not Available
Bull River near Wardner	BC WDR 08NG002	10.61 May 19	~11690			Not Available
Elk River @ Fernie	BC WDR 08NK002	10.09 May 20	9630			Not Available
Tobacco River near Eureka	USGS 12301300	5.98 June 16	2180	12%	8.3	USGS Website* 9/13/2006 based on Bulletin 17b

* http://mt.water.usgs.gov/freq?page_type=table

C. Flood duration frequency estimates.

Flood duration frequency curves also assist in characterizing a runoff event and are provided for two locations: river stage at Bonners Ferry (regulated) and unregulated inflow to Libby Dam. Table 2 shows frequency estimates for Bonners Ferry based on model simulations performed for the Upper Columbia EIS and the one day peaks at Bonners Ferry and Kootenay Lake.

TABLE 2 Flood Duration Frequency Estimates– 2006 Runoff Season

Gage Name	Station Number	Peak Stage Fcst date	Exceed. Freq %	Recurrence Int. Years.	Frequency Curve Source and Date
Bonners Ferry	USGS	1766.6			From Simulations in the Upper

1-Day	12309500	June 18	1.4%	71	Columbia Alternative Flood Control and Fish Operations Final EIS
Bonners Ferry 7-Day Average Elevation (May-July)	USGS 12309500	1765.49 16-22 June 2006	Less than 2%*	Greater than 50-years *	From Simulations in the Upper Columbia Alternative Flood Control and Fish Operations Final EIS
Bonners Ferry 15-Day Average Elevation (May-July)	USGS 12309500	1763.87 9-24 June 2006	Less than 2%*	Greater than 50-years*	From Simulations in the Upper Columbia Alternative Flood Control and Fish Operations Final EIS
Kootenay Lake Queens Bay	USGS 123664	1751.57 June 20	22%	4.5	From Simulations in the Upper Columbia Alternative Flood Control and Fish Operations Final EIS

* The 2006 7- and 15 day average stages at Bonners Ferry are greater than anything simulated, and therefore an exceedance frequency for this year can not be readily assigned. However, from the simulated curves, one can say that both the 2006 7- and 15-day average elevations should have less than a 2%-chance-exceedance frequency, corresponding to an event more extreme than the "50-year" event.

Table 3 shows Libby Dam inflow-frequency curves for maximum one-day, three-day, seven-day, 15-day, 30-day, and 60-day average inflows. The temperatures were unseasonably warm in May, and precipitation was heavy in June. The warm temperatures resulted in low elevation snowmelt and the peak inflow occurring on May 21. The multiple day average inflows can be used to compare the magnitude of the peak of the event with the longer term volume. While the peak occurred a few weeks earlier than average, the peak inflow was about a seven-year event. In other words, a peak inflow of this size could be expected to occur on average once every seven years, or has a 14% chance of occurring each year. The longer term average inflow for one month was a four-year event with a 25% chance of occurring each year. Peak inflows, however, describe only part of the story. Of equal importance is the concentration of volume inflow to Libby Dam. In 2006, the May three-day cumulative inflow volume was the sixth highest of record (for the period of record 1929-2006), the seven-day cumulative inflow volume was the fourth highest of record, and the 14-day cumulative inflow volume was the fifth highest of record. Coincidentally, in 2006, May's volume inflow was 140% of the period of record average. Four of the five years that had higher three-day cumulative inflow volumes than 2006 produced corresponding April through August volumes ranging from 7.85 MAF to 9.14 MAF. Libby's 2006 April through August volume inflow was 6.63 MAF. The three years that had higher seven-day cumulative inflow volumes than 2006 produced corresponding April through August volumes ranging from 7.85 maf to 8.73 MAF. The four years that had higher 14-day cumulative inflow volumes than 2006 produced corresponding April through August volumes ranging from 7.85 maf to 9.14 MA. What the data in this paragraph underscores is that the shape of the May Libby inflow was extremely concentrated and peaked given that the seasonal volume was not much more than average (108%).

TABLE 3 Libby Dam

1-, 3-, 7-, 15-, 30-, 60-day Average Inflow Frequency Estimates – Observed Data – 2006 Runoff Season				
	Average inflow for duration	Exceed. Freq %	Recurrence Interval Years	Frequency Curve Source and Date
Libby Dam Daily Average Peak Inflow 1-day duration	77000	14%	7	Draft – to be reviewed USACE 2006
Libby Dam Daily Average Peak Inflow 3-day duration	75500	14%	7	Draft – to be reviewed USACE 2006
Libby Dam Daily Average Peak Inflow 7-day duration	70414	14%	7	Draft – to be reviewed USACE 2006
Libby Dam Daily Average Inflow 15-day duration	55660	29%	3.5	Draft – to be reviewed USACE 2006
Libby Dam Daily Average Peak Inflow 30-day duration	49763	26%	4	Draft – to be reviewed USACE 2006
Libby Dam Daily Average Peak Inflow 60-day duration	39197	33%	3	Draft – to be reviewed USACE 2006

In summary, the tributary inflows to the Kootenai River and the inflow to Libby Dam were consistently in the range of 1- to 8-year events. Flood peaks of this size occur on a regular basis. The shape of the runoff in May and June had significant departures from average. Record temperatures in May resulted in very rapid snowmelt and a peak in inflow during the second and third week of May. It is important to remember that the most recent streamflow forecast available to the RCC failed to predict the onset of this peak and understimated its magnitude by 38,000 cfs.

The Libby Dam outflow, on the other hand, was greater than a 100-year event. An outflow of this size is a rare event and has not occurred since the construction of Libby Dam. The Bonners Ferry river stage peak is also a rare event that could be expected to occur on average every 71 years, or would have a 1.4% chance of occurring in any one year.